Fiscal Year:	FY 2008	**Task Last Updated:**	FY 10/08/2008
PI Name:	Lang, Thomas F. Ph.D.		
Project Title:	An Integrated Musculoskeletal Countermeasure Battery for Long-Duration Lunar Missions		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Musculoskeletal Alterations Team		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HHC**:Human Health Countermeasures		
Human Research Program Risks:	(1) **Bone Fracture**:Risk of Bone Fracture due to Spaceflight-induced Changes to Bone (2) **Osteo**:Risk Of Early Onset Osteoporosis Due To Spaceflight		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	94143-0649	**Congressional District:**	8
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2007 NSBRI-RFA-07-01 Human Health in Space
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No. of Post Docs:	0	**No. of PhD Degrees:**	8
No. of PhD Candidates:	0	**No. of Master' Degrees:**	1
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	1
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Bloomberg, Jacob (NASA JSC) Grodsinsky, Carlos (ZIN Technologies, Inc.) Sibonga, Jean (USRA) Mulavara, Ajitkumar (USRA) Lee, Stuart (Wyle Integrated Sciences and Engineering Group) Cavanagh, Peter (University of Washington)		
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Task Description:	The degree to which the musculoskeletal system will maintain its integrity during prolonged sojourns in the reduced gravity of the lunar surface is presently unknown. It is, however, likely that without countermeasures there will be adaptive changes in muscle strength, bone mineral density, bone geometry, and sensorimotor status. When the combined effects of these changes are considered in the context of the construction and exploration tasks that will be performed at the lunar base or at other lunar sites, the risk of injury secondary to a fall is likely to be elevated. To address this fundamental problem, we have constructed a compact platform that integrates a time efficient integrated battery of countermeasures that can be conducted in the confines of the lunar habitat to minimize the risk of musculoskeletal injury. Ultimately, we expect that this battery of countermeasures will be validated using a 10° head-up bedrest simulation of a lunar mission, although it could also be tested in the standard 6 degree head down simulation. The specific objectives of the countermeasure battery are: to preserve muscle strength and cardiovascular fitness; to minimize decrements in postural stability, dynamic balance, and the ability to make corrective actions prior to a fall; to preserve functional performance on mission relevant tasks; and to minimize bone loss in the proximal femur. To accomplish these objectives, we have constructed a unique multi-functional countermeasure device which integrates cardiovascular, balance control, and resistance training functions. The stepper system provides cardiovascular exercise. When the stepper is locked down, the device may be utilized for lower body strengthening exercises such as squats, leg extensions and abductor/adductor exercises. To facilitate balance training, the stepper/resistive system is mounted on a Stuart Platform allowing 3D translations with a range of +- 10 cm and pitch/yaw/roll of +-10 degrees. As a next step, during the coming two project years, we will carry out a training study to quantify, in the 1-g setting, increases in cardiovascular function (VO2 max) and lower body strength in 30 volunteers characteristic of the population of the Flight Analog Project Bedrest study. We believe that this study will establish that the gains is muscle strength and VO2max, when the device is used with an exercise prescription simulating its function in bedrest and spaceflight, will be comparable to historical studies in which resistive and cardiovascular exercises have been performed in parallel. We hypothesize that the combined effect of this multifaceted intervention will be to significantly reduce the risk of a work-related falls and subsequent injury. Ultimately, we expect to test our hypothesis in a bedrest study by randomizing half of our subjects to a group which will undergo the integrated countermeasure and the other half to a control group. Pre- and post-bedrest, we will compare indices of balance, muscle strength, and skeletal density and function using a combination of functional and strength tests, serum and urine bone markers and CT and DXA imaging of the hip, spine and tibia.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Outside of the space medicine community, there is a growing appreciation of the importance of an integrated musculoskeletal approach towards prevention of age-related skeletal fractures. Hip fractures, which represent the most serious manifestation of osteoporosis, rarely occur without falls, and the exercise strategies developed here could potentially be adapted to an older demographic, with the same compact exercise and balance countermeasures geared towards reduction of falls and bone loss in the growing population of elderly. We believe that the compact characteristics of the CCD which are optimal for the spaceflight environment will also fulfill the needs for an in-house exercise device or for a nursing home. It is well known that impaired balance is associated with aging and with an increased risk of falling. Balance training exercise in the elderly has been shown to reduce risk of falls. In particular, resistive exercise has been shown to increase muscle strength in the elderly, and increases in muscle strength and balance are associated with improvements in performance and mobility, which are important determinants of quality of life in the elderly. Finally, by focusing on resistive exercise in the abductor and adductor muscle groups, this device is expected both to improve lateral balance and reduce the rate of age-related bone loss by stressing those muscle groups that attach at the hip and thus provide significant mechanical loads on the proximal femur.
Task Progress:	We have completed the first Specific Aim of our NSBRI project, which was to develop a combined countermeasure device (CCD). The CCD combines cardiovascular exercise, neurovestibular stimulation, and lower body strength exercise into a single compact station design of 32" diameter. This design is based on a compact stepper and subject load device (SLD) pneumatic technology. The novel integration of balance and visual cues have been introduced through a Stewart Platform that provides 6 degree of freedom compliance, with a 10 cm range of motion in three axes and ten degree range of rotations in pitch, yaw and roll. The integration of platform, stepper and SLD allows the subject to perform exercise that requires balance motor functions while the platform moves with the exercise motions of the subject. A visual cue will be provided by a stationary LCD display which will be integrated to the platform when bedrest study commences. The use of stepper and SLD pneumatics and provides an integrated platform that is compact and power efficient. For cardiovascular exercise, the stepper is bolted to the platform. The stepper allows for 8" maximum displacement between petals at high stepping rates. Balance training is carried out during the stepping motion, as the subject moves the passive Stewart platform in concert with the displayed visual cues. For resistive lower body exercise, the subject is loaded onto the platform with four pneumatic subject load devices attached to the subject through a shoulder harness. Together, the SLDs provide a maximum resistive load up to 435 lbs in 5 lb increments. The device is designed to support the following resistive exercises: • Squats: 20" maximum vertical displacement with a maximum load up to 435 lbs. This exercise is carried out on an empty platform with the stepper removed. • Abductor/Adductor exercises: the stepper is removed and replaced with a horizontal rail system allowing 15" horizontal leg motion in each direction against a maximum load up to 435 lbs. • Heel raises are performed with the device configured for squats, against a maximum load of 435 lbs. • Leg extensions are carried out with the device configured for squats. A bungee configuration is employed to produce high levels of resistance. The device in its current form will be transferred to UCSF where it will be employed in a training study with the goal of qualifying the CCD for eventual inclusion in the Flight Analog Project bedrest study. For eventual flight status, the device will be redesigned to obviate the need to replace the stepper and horizontal rail adjustment in transition between

	exercise modalities.
Bibliography Type:	Description: (Last Updated: 03/20/2017)